

VIABILITY OF WEED SEEDS AFTER INGESTION BY CALIFORNIA LINNETS

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There has long been question as to whether the birds of the seed-eating family Fringillidae destroy or disseminate weed seeds. Kerner (The Natural History of Plants, London, Blackie & Son, Ltd., 1895, pp. 862-866) fed fruits and seeds of 250 species of plants to various kinds of birds. The feces were examined and laid on a bed of earth with the same fruits and seeds as a control in an adjoining bed. The first group of birds, which includes all the Fringillidae in his experiments (Bull Finch, European Goldfinch, Serin Finch), ground up the fruit and seed in their gizzards and no seeds germinated. In the second group, Ravens and Jackdaws, hard coated seeds passed through the digestive tract uninjured. In the third group, European Blackbird, Song-thrush, Rock-thrush and European Robin, 75 to 88 per cent of the seeds that went through the intestine germinated.

Judd (U. S. Dept. Agric., Biol. Survey Bull., 15, 1901, pp. 49-50) examined the droppings of English Sparrows that had been fed weed seeds and found no whole seeds; he concluded that the sparrows destroyed the seeds. Beal (U. S. Dept. Agric., Biol. Survey. Bulls. 30, 34, 1907, 1910) found that over 86 per cent of the food of California Linnets is composed of weed seeds; he remarks that each linnet destroys several hundred seeds daily and therefore renders a valuable service to agriculture. Beal has also shown that the Wren-tit, the California Thrasher and other local species spread the seeds of poison oak.

Collinge (The Food of some British Wild Birds: a Study of Economic Ornithology, York, 1924-27) admits "that birds annually destroy a large quantity of the seeds of various weeds." But he found when he planted the droppings from House (English) Sparrows, Greenfinches, and Bullfinches in sterile soil that a good many weeds grew. He makes no statement as to the number of weed seeds eaten and hence draws no conclusions as to the percent of seeds destroyed or disseminated. He concludes that "in dry years such birds as the Rook, the Starling, the House-Sparrow (and probably many other species) take in a smaller quantity of grit and soil than in wet years, in consequence of which a larger percentage of weed seeds pass through the intestinal canal in an uninjured condition."

In the present experiments, California Linnets (*Carpodacus mexicanus frontalis*) were fed carefully counted numbers of weed seeds. The droppings were planted in boxes containing steam-sterilized soil and kept under greenhouse conditions in order to determine what per cent of the weed seeds eaten were viable after passage through the digestive tracts of the birds. Two pairs of linnets were kept in an outdoor cage three by three by six feet in size, that allowed some room for exercise. Millet, canary, rape and sunflower seeds, fresh fruit, sand, and gravel were always available to the birds, even during the experiments.

For each experiment the cage was thoroughly cleaned and the floor was completely covered with a sheet of paper. The weed seeds and other foods were placed in small dishes inside of a pan a foot square with sides four inches high that practically prevented scattering of the seed. Eight hours after the last weed seeds were eaten, the paper, with all the droppings that had been passed, was removed from the cage and the droppings placed on sterile soil in one half of a divided "flat." Some of the droppings were broken up as they were transferred to the soil; others were kept intact.

Just enough sterile soil was sprinkled over the droppings to keep them from washing. The other half of each flat was used as a control by planting 100 seeds of each species of seed used in the experiment. The flats were kept in a cold frame and watered daily, unless otherwise noted; the number of germinations was observed daily.

Table 1 presents the results of these experiments. Time in days means length of time it took the seeds to germinate; where there has been no germination it means the length of the period over which droppings and control seeds have been under observation.

TABLE 1
GERMINATION OF WEED SEEDS IN STERILE SOIL AFTER PASSAGE THROUGH LINNETS

Species of weed seed used	Number of seeds fed to birds	Germination from droppings		Germination of control seeds	
		Number	Time (days)	Per cent	Time (days)
Bermuda grass (<i>Cynodon dactylon</i>)	375	1	10	90	14
Blow-wives (<i>Achyraea mollis</i>)	500	0	70	0	70
Canary seed (<i>Phalaris canariensis</i>)	1000	0	31	54	7
Dandelion (<i>Taraxacum officinale</i>)	500	0	85	54	13
Flax (<i>Linum usitatissimum</i>)	2000	0	62	58	7
German millet (<i>Panicum germanicum</i>)	1000	0	31	73	7
German millet (<i>Panicum germanicum</i>)	2000	0	85	73	7
Lettuce (<i>Lactuca</i> sp.)	2000	0	62	30	8
Rape (<i>Brassica napus</i>)	1000	0	31	80	7
Red millet (<i>Panicum miliaceum</i>)	1000	0	70	60	4
Thistle (<i>Gnuzotia abyssinica</i>)	2000	0	62	40	7
Wild mustard (<i>Brassica arvensis</i>)	200	0	31	51	13
Wild mustard (<i>Brassica arvensis</i>)	500	0	85	60	12
Yellow burweed (<i>Amsinckia intermedia</i>)	500	0	70	0	70

Since long contact with the droppings might possibly destroy the viability of fragments of included seed, in the next set of experiments smaller sheets of paper were put under the perches, in addition to the sheet of paper over the whole floor, and the droppings then collected at hourly intervals and planted and watered immediately, while they were still moist. At the end of the experiment the droppings from the large sheet of paper were also planted. The results of these tests appear in table 2. All germination from droppings were from those evacuated seven hours after the presentation of the weed seeds with the exception of the dandelion seed in which the interval was six hours.

TABLE 2
GERMINATION OF WEED SEEDS FROM DROPPINGS COLLECTED HOURLY

Species of weed seed used	Number of seeds fed to birds	Germination from droppings		Germination of control seeds	
		Number	Time (days)	Per cent	Time (days)
Alfilaria (<i>Erodium cicutarium</i>)	700	0	190	74	20
Bermuda grass (<i>Cynodon dactylon</i>)	2000	1	180	26	150
Chickweed (<i>Stellaria media</i>)	600	1	160	80	180
Dandelion (<i>Taraxacum officinale</i>)	900	1	165	32	180
Flax (<i>Linum usitatissimum</i>)	2000	0	190	60	8
Lettuce (<i>Lactuca</i> sp.)	2000	0	190	34	8
Shepherds Purse (<i>Capsella bursa-pastoris</i>)	2000	1	160	6	180
Thistle (<i>Gnuzotia abyssinica</i>)	2000	0	190	64	8
Wild mustard (<i>Brassica arvensis</i>)	2000	0	190	74	20

An effort was made to determine whether lack of a supply of grit or whether availability of fruit had any bearing on the digestion of weed seeds. In one experiment both grit and fruit were withheld for 53 hours previous to and during the experiment. In another, grit was similarly withheld but fruit was generously supplied in the form of ripe apples and strawberries. It is generally understood that birds retain grit, sometimes for long periods of time, when no additional supply is available. The withholding

of fresh supplies for two days would, therefore, probably reflect but little difference in effect, if any, by this procedure, upon the passage of viable seeds.

As weed seeds in sufficient quantities were difficult to obtain, much of the seed used was gathered by the writer during the experiments. Such fresh seed had not passed through its dormant period and that of some species would not germinate for many months. While this is typical of field conditions and might be advantageous in obtaining a true picture of the results of weed seed feeding by linnets, it imposed certain restrictions upon the experiments. It was necessary to do each experiment in duplicate; one set of flats was kept damp, the others were allowed to dry out during the summer as does the soil in the field. Watering of the latter was resumed with the first fall rain, on October 1.

In Table 3 results of both sets of experiments are given. Germinations from droppings were from those evacuated four hours after the presentation of the seeds.

TABLE 3
GERMINATION OF WEED SEEDS FROM GRIT AND FRUIT EXPERIMENTS

Species of weed seed used	Number of seeds fed to birds	No grit, no fruit Flats allowed to dry				No grit, no fruit Flats kept wet Droppings planted hourly				No grit, much fruit Flats allowed to dry				No grit, much fruit Flats kept wet Droppings planted hourly			
		Droppings		Controls		Droppings		Controls		Droppings		Controls		Droppings		Controls	
		Number	Time	Per cent	Time	Number	Time	Per cent	Time	Number	Time	Per cent	Time	Number	Time	Per cent	Time
Alfilaria (<i>Erodium cicutarium</i>)	250	0	160	0	160	0	165	2	92	0	150	0	150	0	140	0	140
Blow-wives (<i>Achyraea mollis</i>)	250	0	160	0	160	0	165	0	165	0	150	0	150	0	140	0	140
Chickweed (<i>Stellaria media</i>)	250	0	160	0	160	1	155	14	165	0	150	0	150	0	140	56	140
Dandelion (<i>Taraxacum officinale</i>)	250	0	160	16	18	0	165	0	165	0	150	0	150	0	140	28	140
Flax (<i>Linum usitatissimum</i>)	250	0	160	40	6	0	165	62	10	0	150	40	6	0	140	80	4
Lettuce (<i>Lactuca</i> sp.)	250	0	160	20	6	1	4	8	4	0	150	20	6	0	140	10	4
Thistle (<i>Guizotia abyssinica</i>)	250	0	160	30	6	0	165	38	10	0	150	30	6	0	140	24	4
Wild mustard (<i>Brassica arvensis</i>)	250	0	160	66	18	0	165	64	10	0	150	66	18	0	140	16	4
Yellow burweed (<i>Amsinckia intermedia</i>)	250	0	160	0	160	0	165	12	140	0	150	0	150	0	140	6	125

A few droppings (15) from wild linnets were planted; these were collected by placing bread crumbs and strawberries on a large sheet of paper on the ground. Some droppings (8) of wild White-crowned Sparrows (*Zonotrichia leucophrys gambelii*) were similarly collected and planted in sterile soil. One box was kept damp and the other allowed to dry out during the summer; the latter was watered again, beginning October 1. The material of each dropping was planted separately. The flats were inspected daily. No germinations resulted in a period of 190 days.

Observations on the feeding habits of the linnets showed that each seed that is to be eaten is very carefully hulled. Seeds with hard shells, such as those of morning glory and bur clover, were ignored as were minute seeds like those of poppy and mayweed. From a dish of mixed seeds of various sizes, such as chickweed, hemp, lettuce, pigweed, and thistle, each linnet ate approximately 1000 to 1200 seeds per day.

The seeds eaten, in order of preference, were:

- Thistle (*Guizotia abyssinica*)
- Hemp (*Cannabis sativa*)
- Flax (*Linum usitatissimum*)
- Rough pigweed (*Amaranthus retroflexus*)
- Alfilaria (*Erodium cicutarium*)

Blow-wives (*Achyrachaena mollis*)
 Yellow burweed (*Amsinckia intermedia*)
 Wild mustard (*Brassica arvensis*)
 Canary seed (*Phalaris canariensis*)
 Rape (*Brassica napus*)
 Dandelion (*Taraxacum officinale*)
 Common sow thistle (*Sonchus oleraceus*)
 Curled dock (*Rumex crispus*)
 Lettuce (*Lactuca* sp.)
 Chickweed (*Stellaria media*)
 Sunflower (*Helianthus annuus*)
 German millet (*Panicum germanicum*)
 Hog millet (*Panicum miliaceum*)
 Bermuda grass (*Synodon dactylon*)
 Shepherd's purse (*Capsella bursa-pastoris*)

Other foods eaten were: strawberries, apples, cracker crumbs, yolk of hard boiled egg and ground red pepper.

Foods offered but not eaten included seeds of the following species:

Morning glory (*Convolvulus arvensis*)
 Wild oats (*Avena fatua*)
 Pine nuts (shelled or unshelled)
 Bur clover (*Medicago hispida*)
 Sour clover (*Medicago* sp.)
 Cheat or chess (*Bromus secalinus*)
 Wild barley (*Hordeum jubatum*)
 Poppy (*Papaver somniferum*)
 Mayweed (*Anthemis cotula*)

In summary, of 40,025 experimental seeds eaten by the linnets, only 7 germinated. The single seed of shepherd's purse that germinated after going through a bird was one of 2000; however, since the control germination for this seed showed only 6 per cent viability in that experiment, it is safer to conclude that one of 120 viable shepherd's purse seeds ingested by linnets might germinate under appropriate conditions. The ratios of the other germinations as between droppings and controls are: Bermuda grass, 2:858; chickweed, 2:515; dandelion, 1:288; lettuce, 1:20.

It is interesting to note that in six of these seven cases the droppings were planted while still moist and watered immediately so that any destructive action due to long contact with the dropping was eliminated. In the seventh case the dropping may have been fresh when planted. In all these seven cases the seeds involved are small and presumably more difficult for the bird to hull than are larger seeds. It is possible that all seven seeds were accidentally swallowed whole by the birds and, because of their protective hulls, passed uninjured through their digestive tracts.

Since linnets live almost exclusively on seeds and must therefore digest most of them to live, and since even under favorable conditions there are very few germinations from the remains of seeds in the droppings, it seems safe to conclude that linnets do not spread weed seeds to any appreciable extent, if at all. On the contrary, each linnet probably destroys about 1000 seeds daily.

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